References

1) **So et Al** (JP09-215982, own application): single electrode and a batch device for electrochemical reaction in hydrothermal cond.

2) **Spears** (US5,599,296): apparatus for gas saturation of liquids by increasing partial pressure of gas preventing gas bubbles.

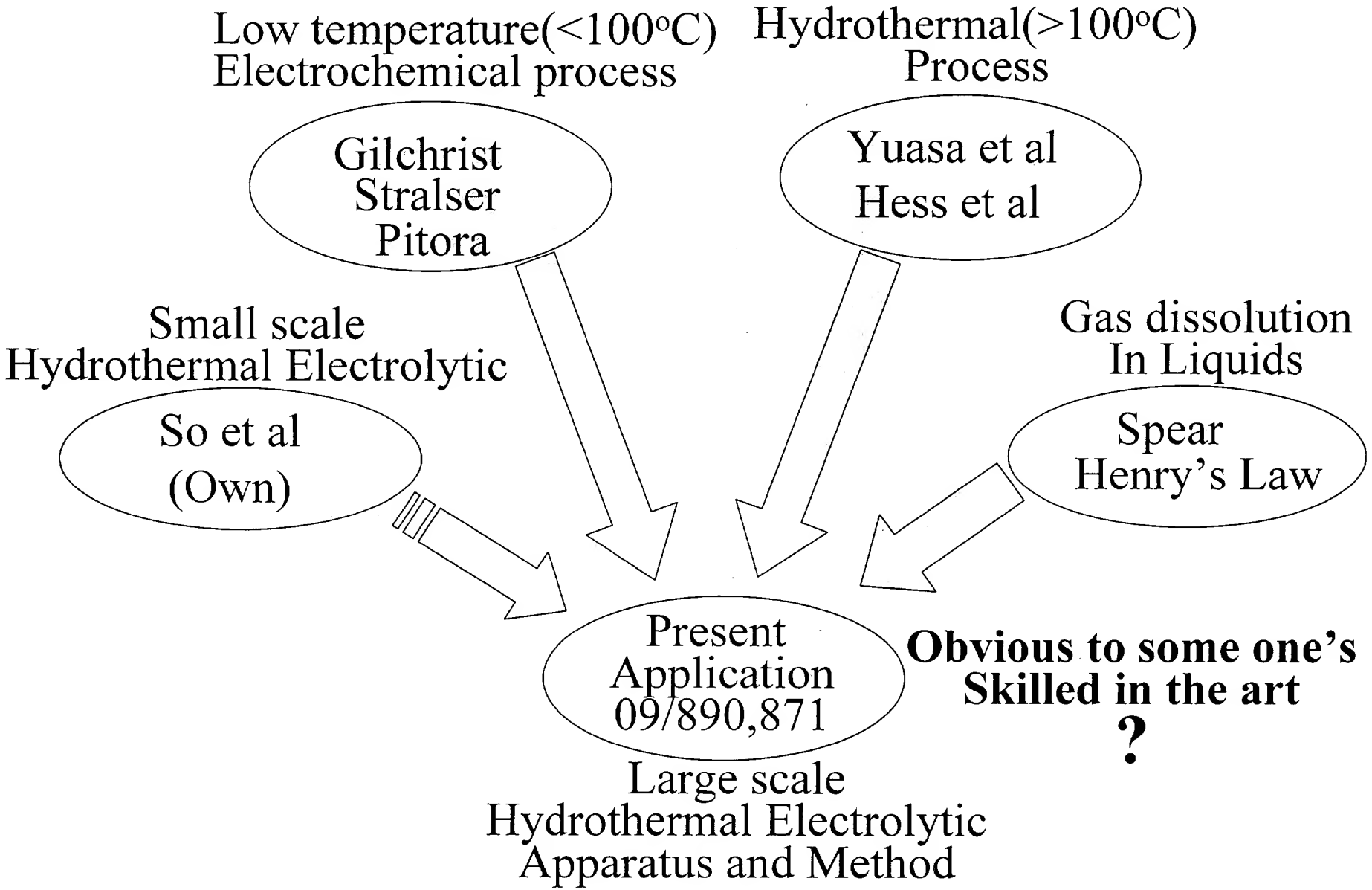
3) **Gilchrist** (US3,798,150): multiple tubular electrolytic cells and pressure apparatus for separation of electrodepositable material from liquids operating at 54-64°C.

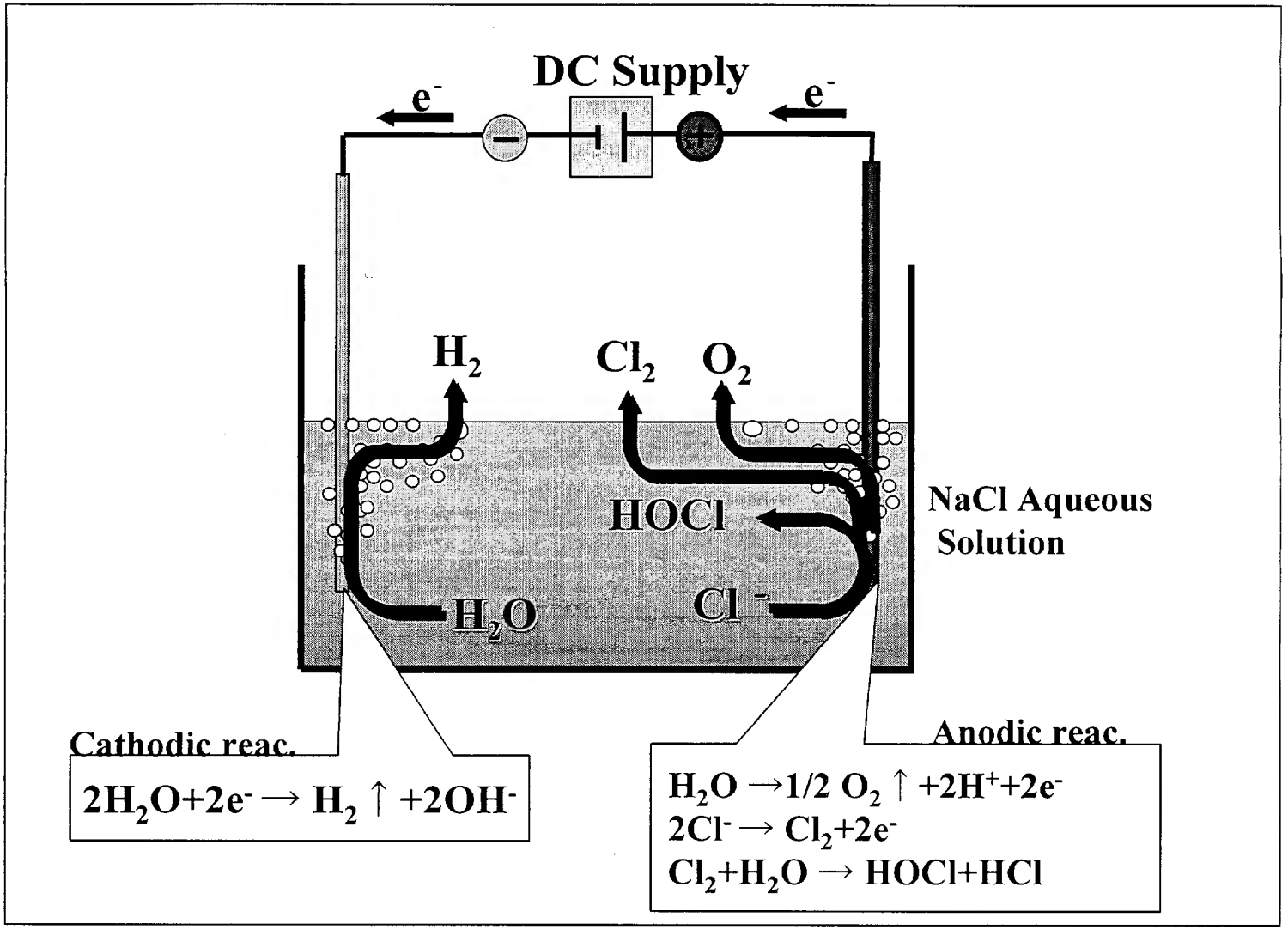
4) **Stralser** (US3,975,247): concentrically tubular electrolytic cells apparatus for treatment of swages for recovering water and solids; room temperature (15-26°C) .

5) **Yuasa et al** (JP09-117782): Hydrothermal oxidation method and apparatus for treating ammonia waste using catalyst and oxidizer.

6) **Pitora et al** (SU 962212): Electrochemical apparatus using conductive particles for treatment of wastewater (No suggestion of Hydrothermal)

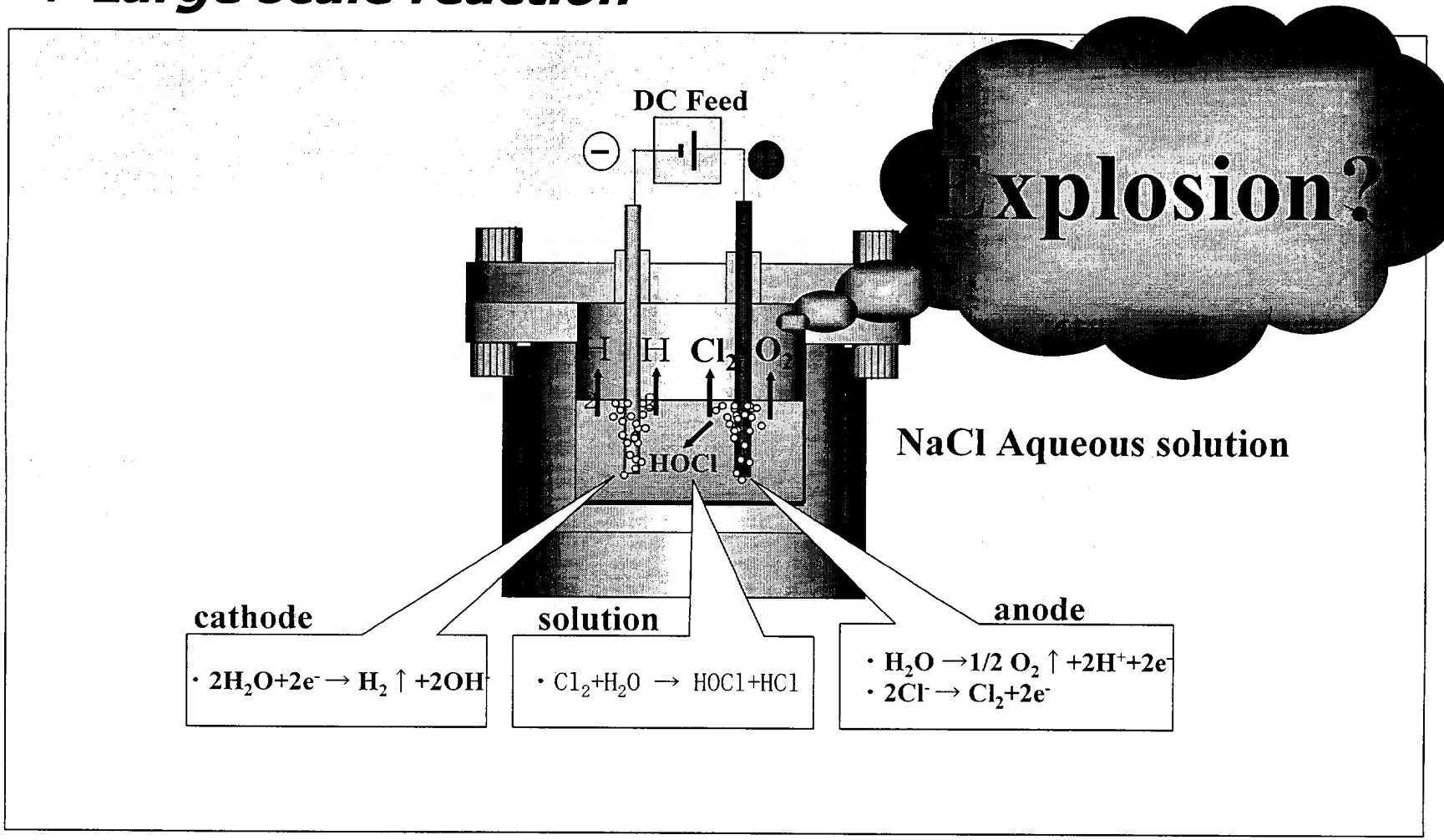
7) **Hess et al** (US3,652,405): Hydrothermal (400-750°C) method and apparatus for treatment of municipal refuse and sewage with separation of solids products by hydrocyclones and filters).

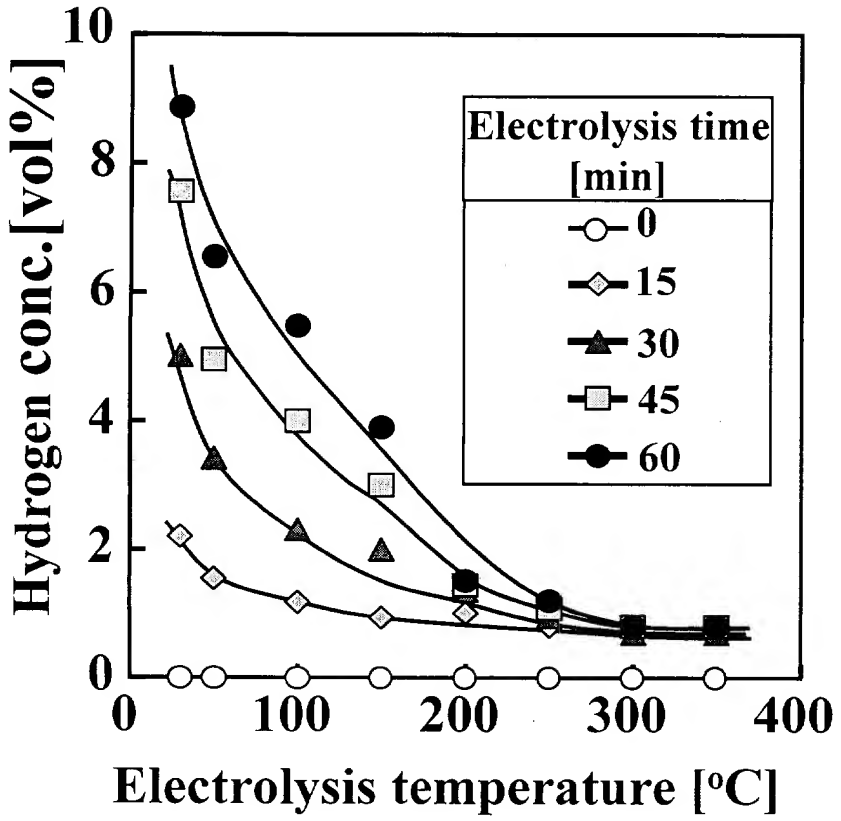

Low temperature(<100°C)
Electrochemical process
Hydrothermal(>100°C)
Process
Gilchrist
Stralser
Pitora
Yuasa et al
Hess et al
Small scale
Hydrothermal Electrolytic
Gas dissolution
In Liquids
So et al
(Own)
Spear
Henry's Law
Present
Application
09/890,871
Obvious to some one's
Skilled in the art
?
Large scale
Hydrothermal Electrolytic
Apparatus and Method

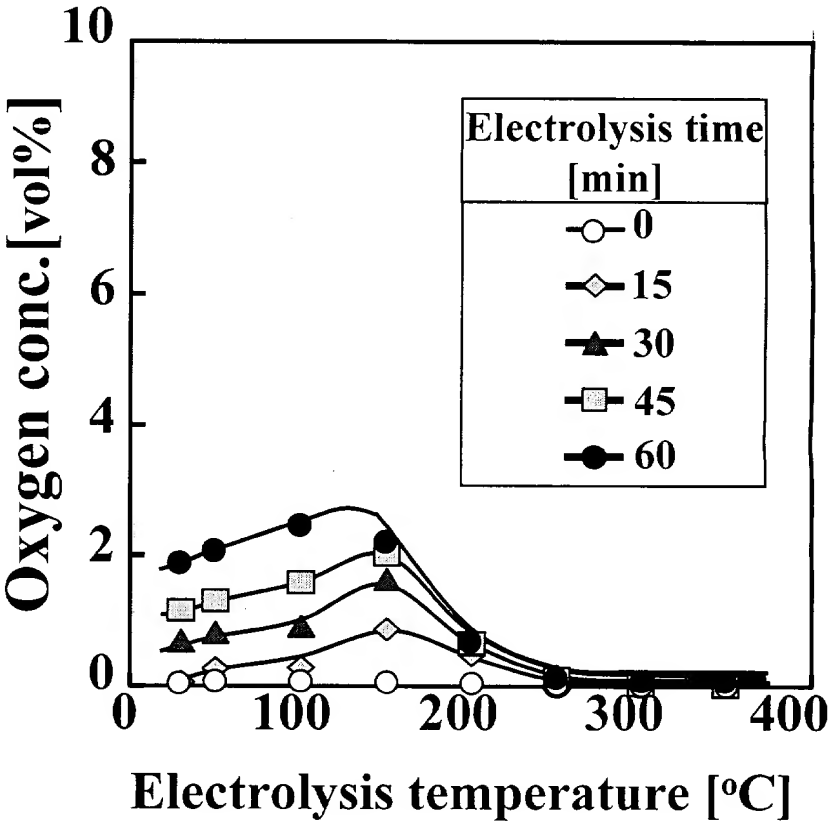


What is know: Electrolysis of aqueous solution at up to 100°C

Non Obviousness of combination of prior art: Electrochemical reaction + Hydrothermal reaction + Large scale reaction

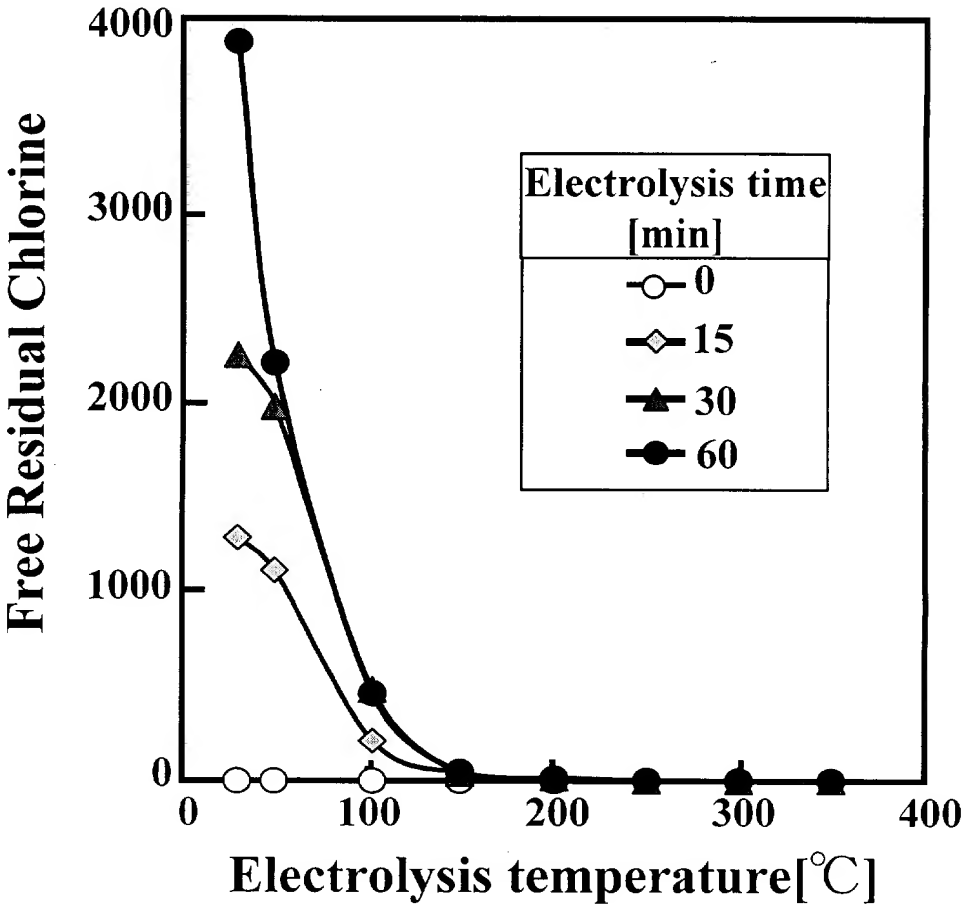






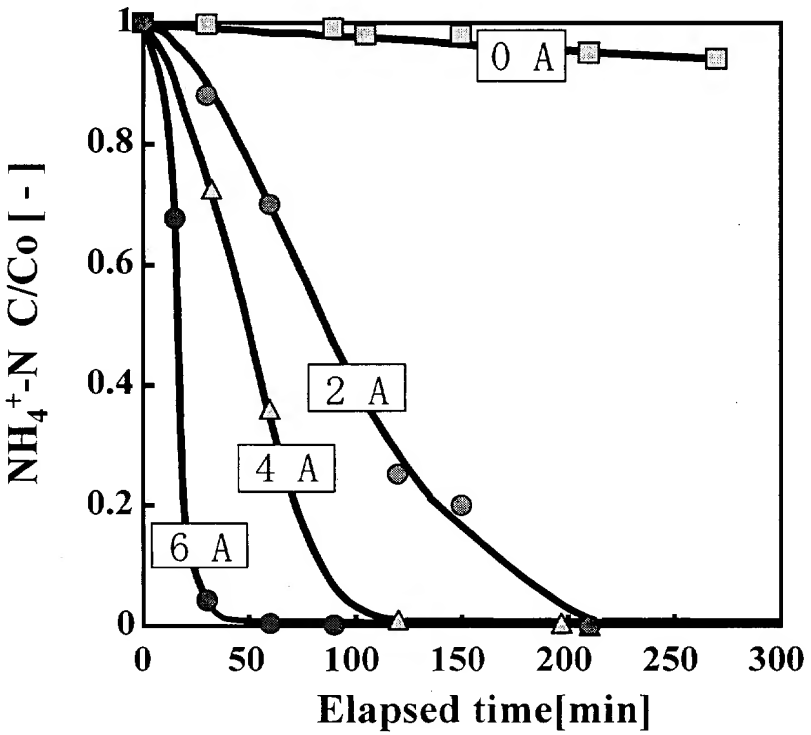
Influence of temperature on the electrolysis of aqueous NaCl solution: gas product

150mL NaCl 2wt%, DC 2A, initial charged gas 3MPa Ar

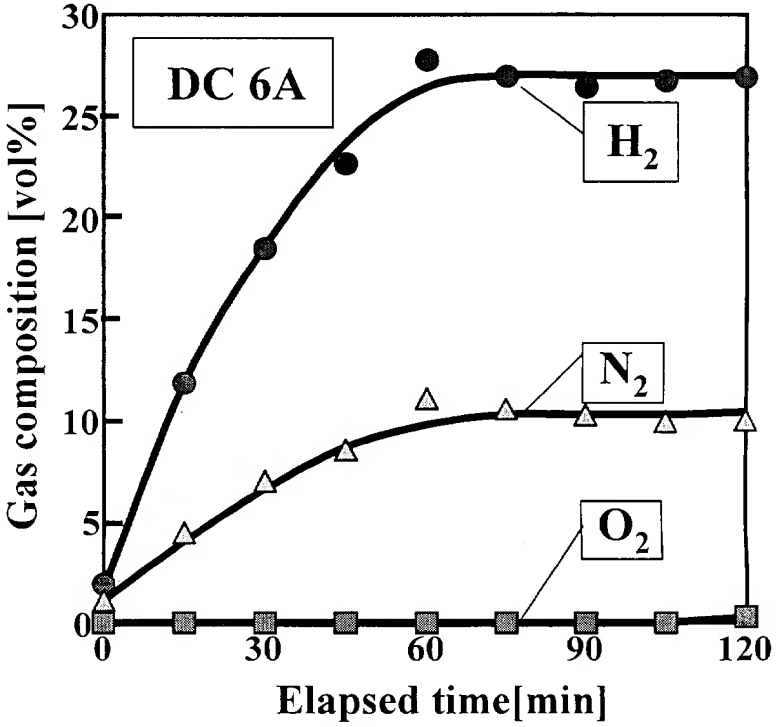


Influence of temperature on the electrolysis of aqueous NaCl solution : HOCl analysis

150mL NaCl 2wt%, DC 2A, initial charged gas 3MPa Ar



NH_4^+-N Concentration profile

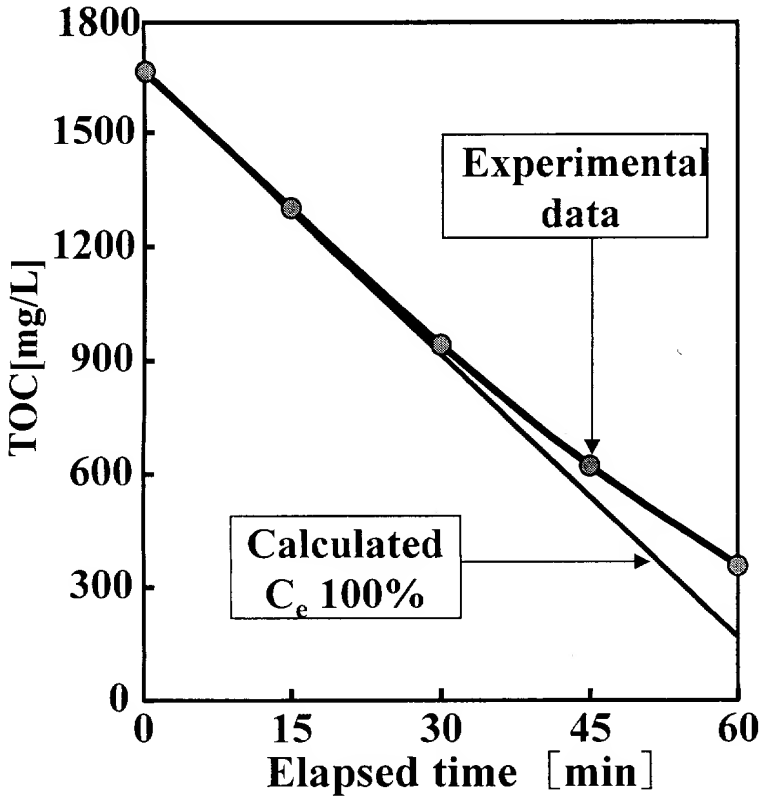


Gas Composition profile

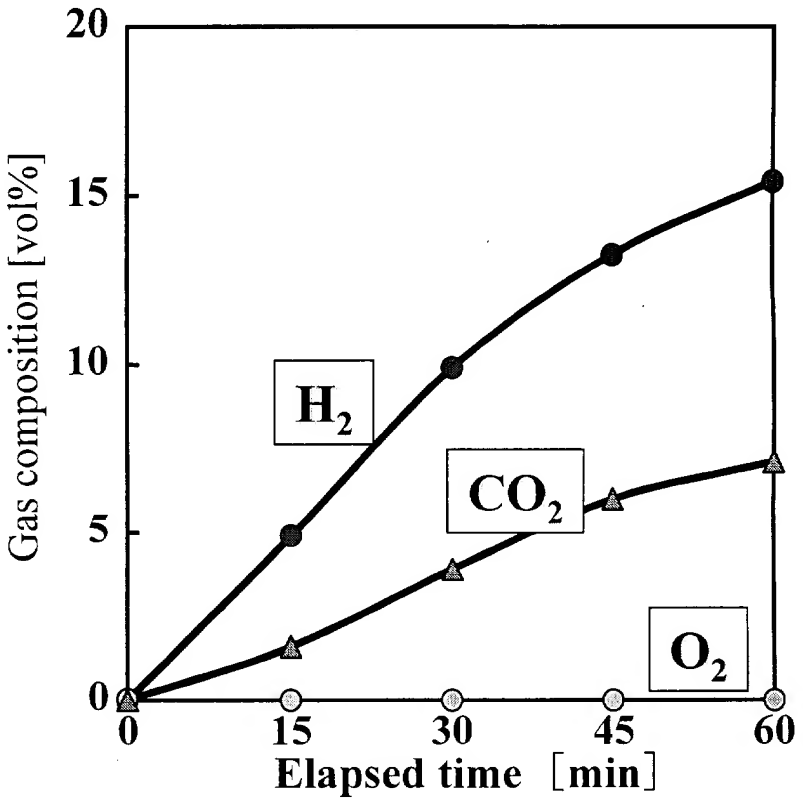
Electrochemical Oxidation of Ammonia at subcritical water conditions

Reaction conditions: Initial NH_4^+-N, 3,000mg/L T, 250℃ P, 7MPa NaCl , 2wt%

$$2NH_3 \rightarrow N_2 \uparrow + 3H_2 \uparrow$$



TOC removal profile

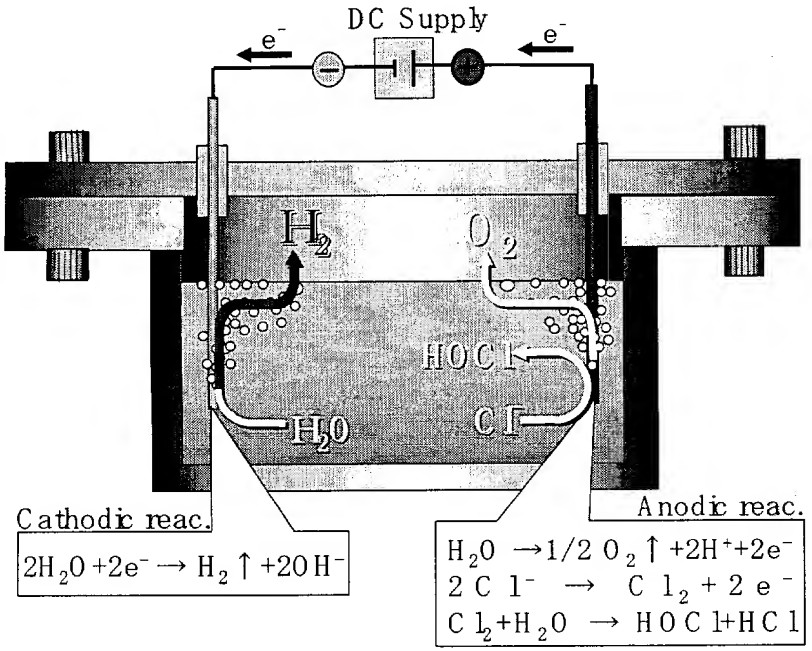


Gas composition profile

Current Efficiency for electrochemical oxidation of acetic acid

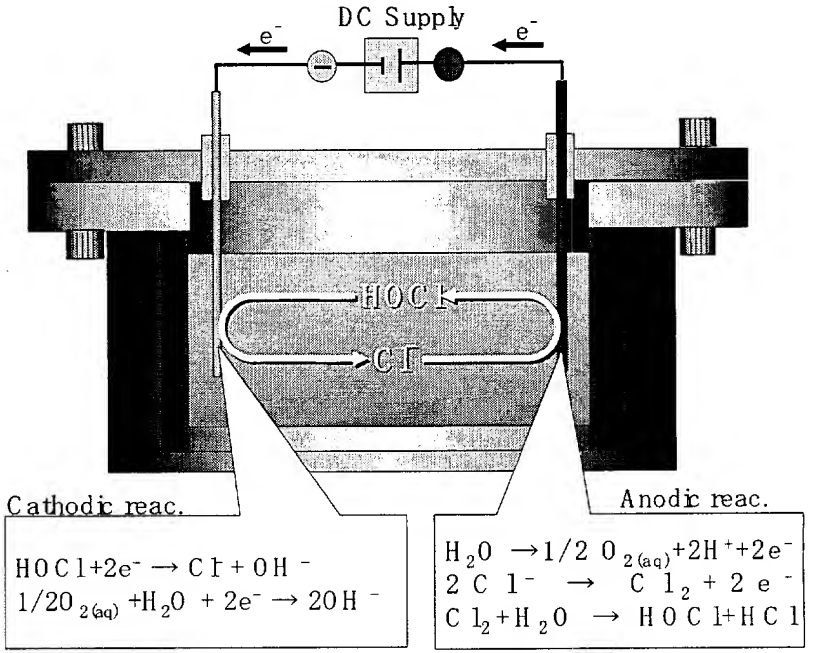
Experimental condition: Acetic Acid, 4,000mg/L; T, 250℃ ; P, 7MPa; NaCl, 2wt%; DC, 2A

$$CH_3COOH + 2H_2O \rightarrow 2CO_2\uparrow + 4H_2\uparrow$$



~100℃

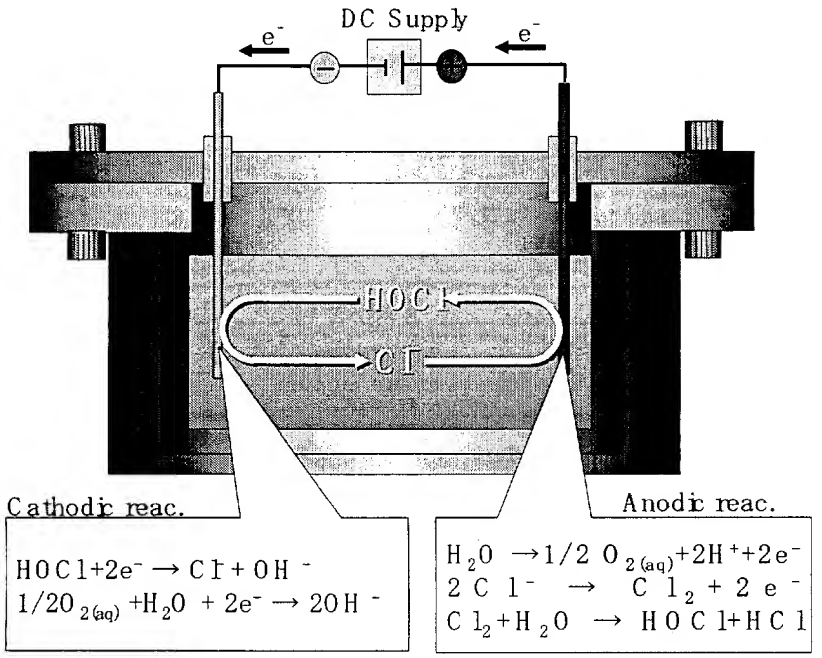
Conventional Electrolysis



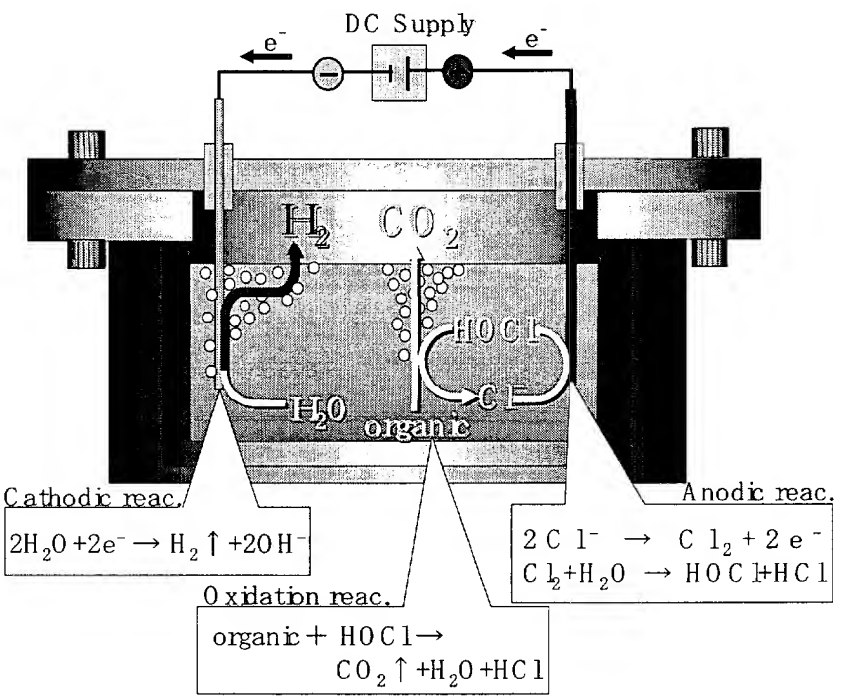
250℃, 7MPa

Hydrothermal water electrolysis

Reaction scheme for electrochemical reaction of aqueous NaCl (strong acidic ions) at hydrothermal conditions

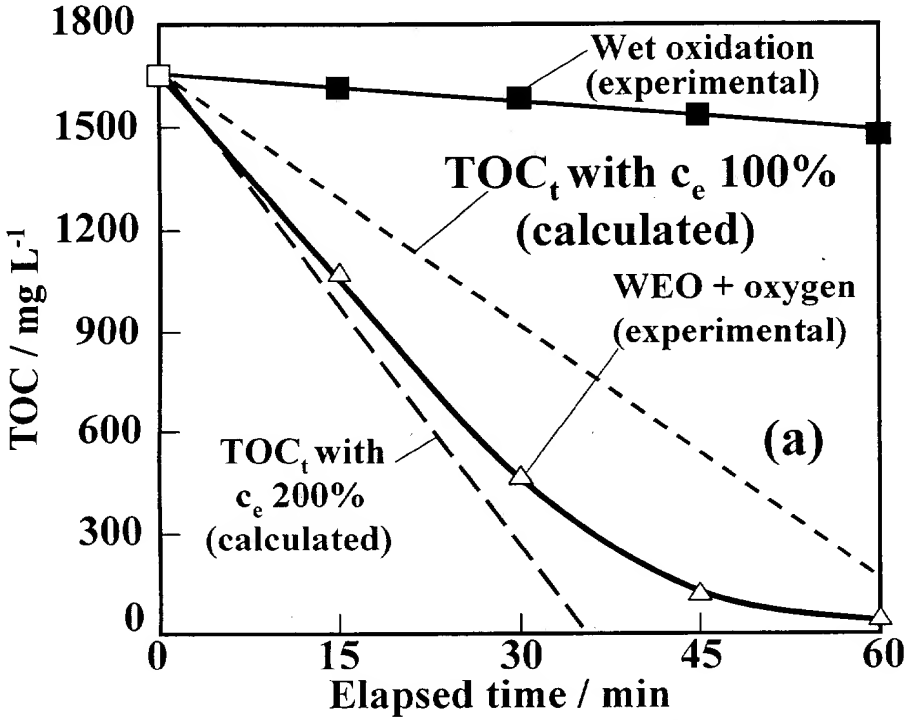


Conditions: 250℃, 7MPa for example
Electrolysis without reducing compounds

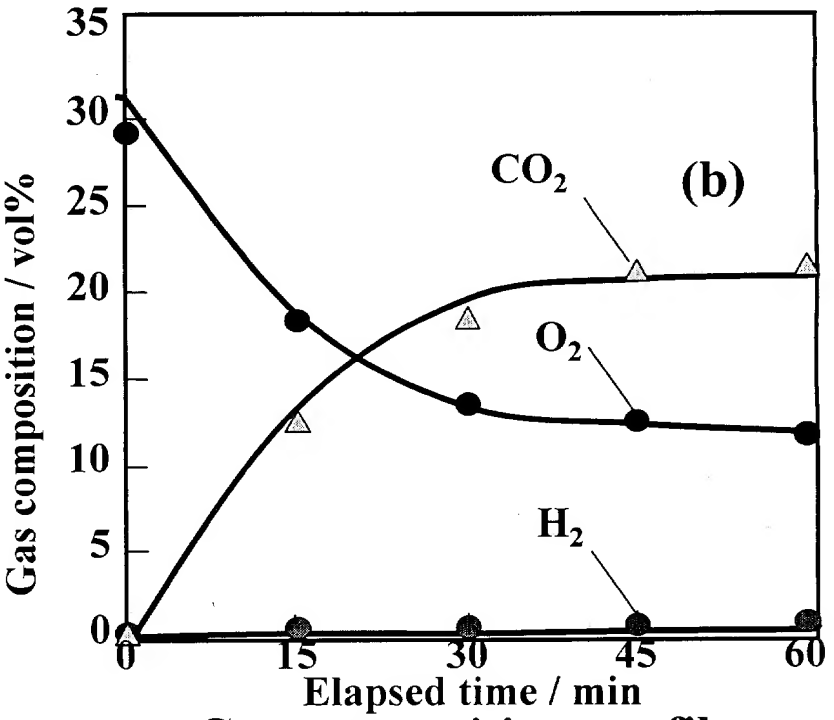


Condition: 250℃, 7MPa for example
Electrochemical oxidation with reducing compounds

Scheme for electrochemical reaction of reducing compounds at hydrothermal conditions



TOC removal profile

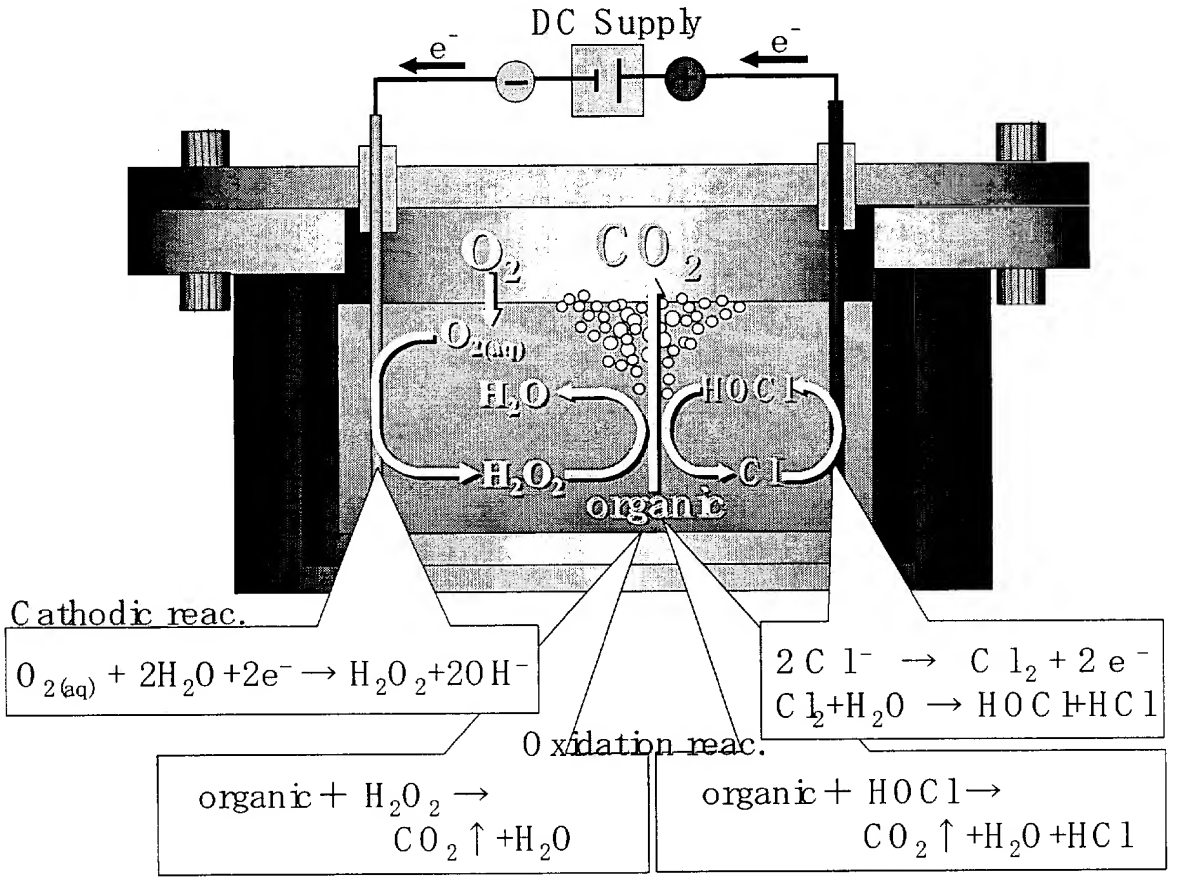


Gas composition profile

Electrochemical reaction of Acetic acid at hydrothermal conditions with addition of oxidizer

Experimental condition: Acetic Acid, 4,000mg/L; T, 250℃ ; P, 7MPa; NaCl, 2wt%; DC, 2A

$$CH_3COOH + 2O_2 \rightarrow 2CO_2 \uparrow + 2H_2O \uparrow$$



Conditions: 250℃, 7MPa for example

Electrochemical oxidation of organics with oxidizer addition

Scheme for electrochemical reaction of reducing compounds at hydrothermal conditions

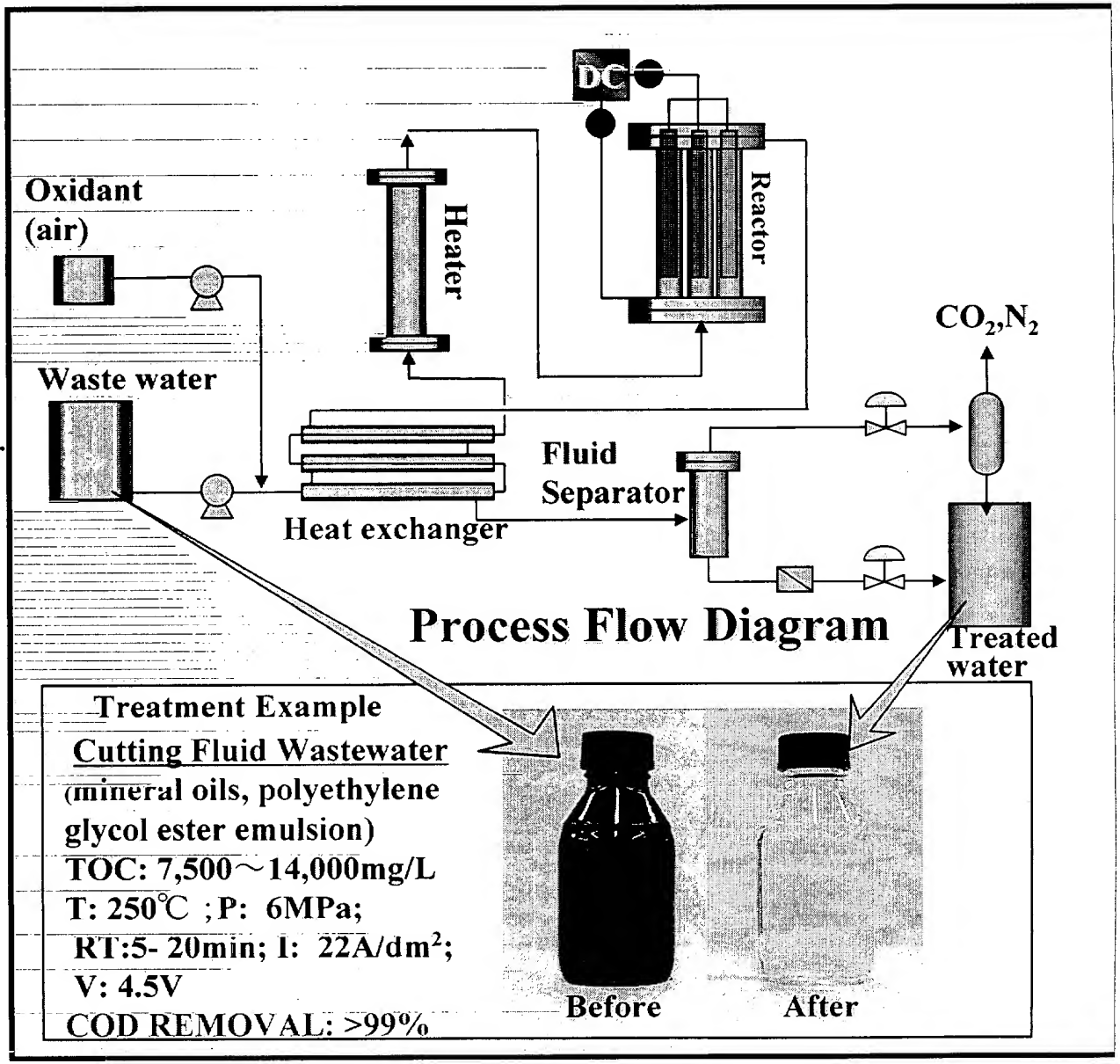
Hydrothermal Electrolytic Oxidation Process

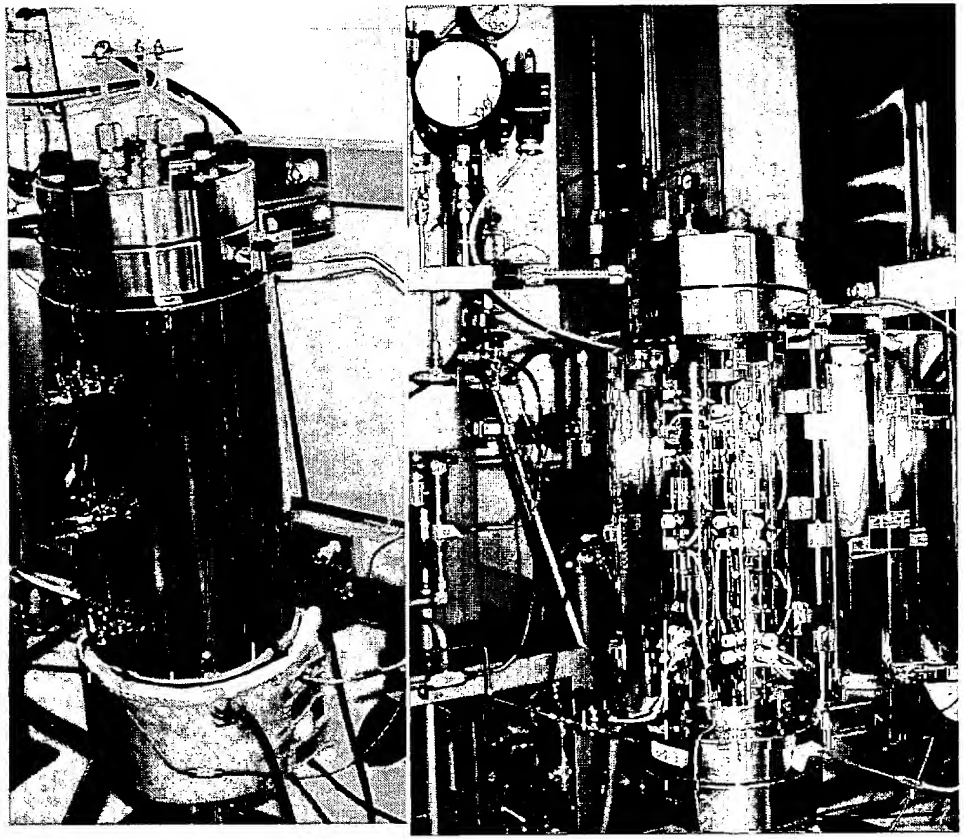
A new treatment technology for refractory industrial wastewater

- Complete removal of wastewater COD to innocuous CO_2, N_2 and water
- High decomposition rate(over 99%)
- Short residence time(5 to 20min)
- Mild reaction condition (100-374℃、3-25MPa)
- Closed system
- Compact installation
- Costly competitive process
- High safety installation (Low voltage electrolysis, system inter-lock)

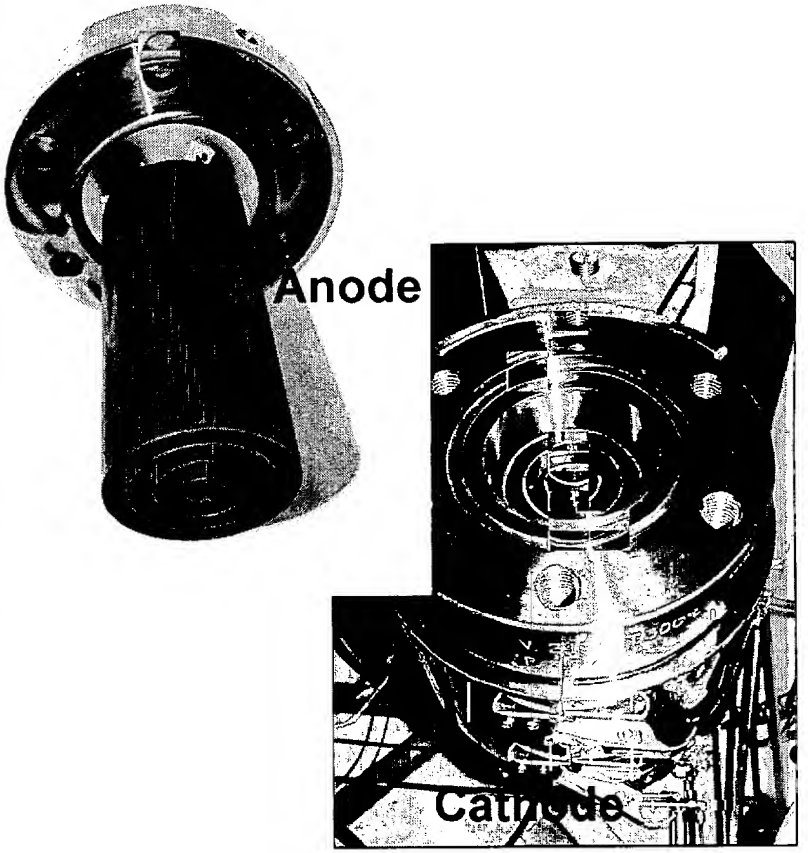
- Highly loaded COD wastewater
- Wastewater with high salt contents
- Example:

Semi-conductor industry wastewater
Agro-Chemical industry wastewater
Chemical industry wastewater,
Pharmaceutical industry wastewater,
Dyes wastewater,
Power plant wastewater
Cutting Fluid wastewater etc.





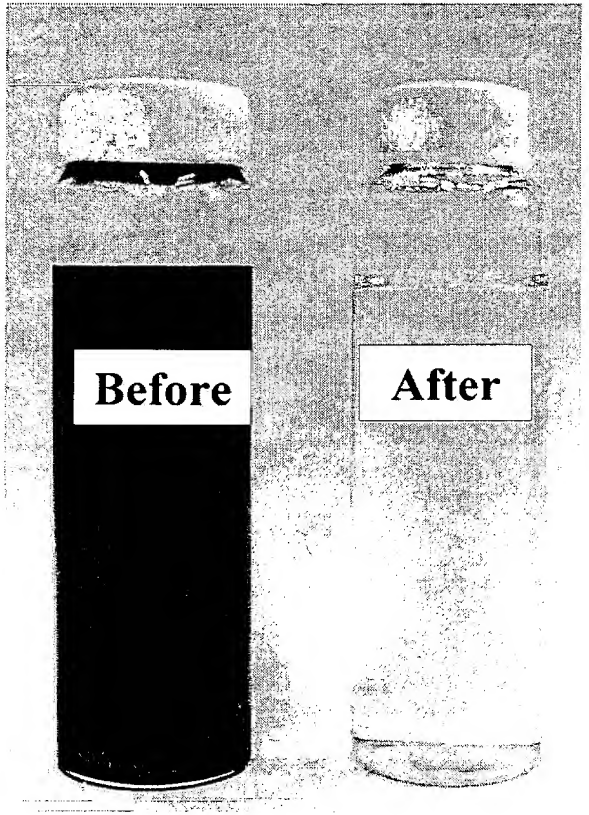
Multiple cylinder electrode reaction cell type



Concentrically cylinder Electrode reaction cell type

Embodiments of Electrochemical Reactor for Hydrothermal Conditions

Examples of industrial wastewater treated by HEO



Photo&film processing laboratory wastewater

TOC removal: 97%
COD removal: 97%
Color Removal:99.9%

Machinery wastewater (cutting fluid)

N-Hex removal: 99%
TOC removal: 95%
COD removal: 92%
Color removal: 99.9%

Agro-chemical Industry wastewater

AOX removal: 98%
TOC removal: 88%
COD removal: 90%
Color removal:99%

The information disclosed here, are shown in present application and/or

1) US6,348,143(WO99/07641) Serikawa et Al, incorporated in entirety to this application
2) Serikawa et al., J.Applied Electrochemistry, 30, July 2000, pg 875-883

Thank you for interview opportunity
And you kind attention